Laparoscopically assisted abdominal aortic aneurysm repair: First 20 cases

Roxana G. Kline, MD, Anthony J. D'Angelo, MD, Marie H. M. Chen, MD, Vivienne J. Halpern, MD, and **Jon R. Cohen, MD,** *New Hyde Park, N.Y.*

Purpose: **Laparoscopic surgery decreases postoperative pain, shortens hospital stay, and returns patients to full functional status more quickly than open surgery for a variety of surgical procedures. This study was undertaken to evaluate laparoscopic techniques for application to abdominal aortic aneurysm (AAA) repair.**

Methods: **Twenty patients who had AAAs that required a tube graft underwent laparoscopically assisted AAA repair. The procedure consisted of transperitoneal laparoscopic dissection of the aneurysm neck and iliac vessels. A standard endoaneurysmorrhaphy was then performed through a minilaparotomy using the port sites for the aortic and iliac clamps. Data included operative times, duration of nasogastric suction, intensive care unit days, and postoperative hospital days. Pulmonary artery catheters and transesophageal echocardiography were used in seven patients. For these patients data included heart rate, pulmonary artery systolic and diastolic pressures, mean arterial pressure, central venous pressure, pulmonary capillary wedge pressure, cardiac index, and end diastolic area. Data were obtained before induction, during and after insufflation, during aortic cross-clamp, and at the end of the procedure.**

Results: **Laparoscopically assisted AAA repair was completed in 18 of 20 patients. Laparoscopic and total operative times were 1.44 ± 0.44 and 4.1 ± 0.92 hours, respectively. Duration of nasogastric suction was 1.3 ± 0.7 days. Intensive care unit stay was 2.2 ± 0.9 days. The mean length of hospital stay was 5.8 days excluding three patients who underwent other procedures. There were two minor complications, one major complication (colectomy after colon ischemia), and no deaths. For the eight patients who had intraoperative transesophageal echocardiographic monitoring, no changes were noted in heart rate, pulmonary artery systolic pressure, pulmonary capillary wedge pressure, and cardiac index. Pulmonary artery diastolic pressure and central venous pressure were greatest during insufflation without changes in end-diastolic area. Volume status, as reflected by end-diastolic area and pulmonary capillary wedge pressure, did not change.**

Conclusions: **Laparoscopically assisted AAA repair is technically challenging but feasible. Potential advantages may be early removal of nasogastric suction, shorter intensive care unit and hospital stays, and prompt return to full functional status. The hemodynamic data obtained from the pulmonary artery catheter and transesophageal echocardiogram during pneumoperitoneum suggest that transesophageal echocardiography may be sufficient for evaluation of volume status along with the added benefit of detection of regional wall motion abnormalities and aortic insufficiency. Further refinement in technique and instrumentation will make total laparoscopic AAA repair a reality. (J Vasc Surg 1998;27:81-8.)**

Abdominal aortic surgery has advanced dramatically over the past 50 years as a result of improvements in anesthesia and surgical techniques. The morbidity and mortality rate for elective abdominal aortic aneurysm repair is now routinely between 3% and 5%.[1] Although open abdominal aortic aneurysm (AAA) repair is a proven, reliable approach for this disease, exposure of the abdominal aorta requires a long midline or flank incision and extensive retroperitoneal dissection, which contribute to large fluid shifts, pro-

From the Department of Surgery, Long Island Jewish Medical Center.

Presented at the Forty-fifth Scientific Meeting of the International Society for Cardiovascular Surgery, North American Chapter, Boston, Mass., June 3–4, 1997.

Reprint requests: Jon R. Cohen, MD, Chairman, Department of Surgery, Long Island Jewish Medical Center, 270-05 76th Ave., New Hyde Park, NY 11040.

0741-5214/98/$5.00 + 0 **24/6/86072**

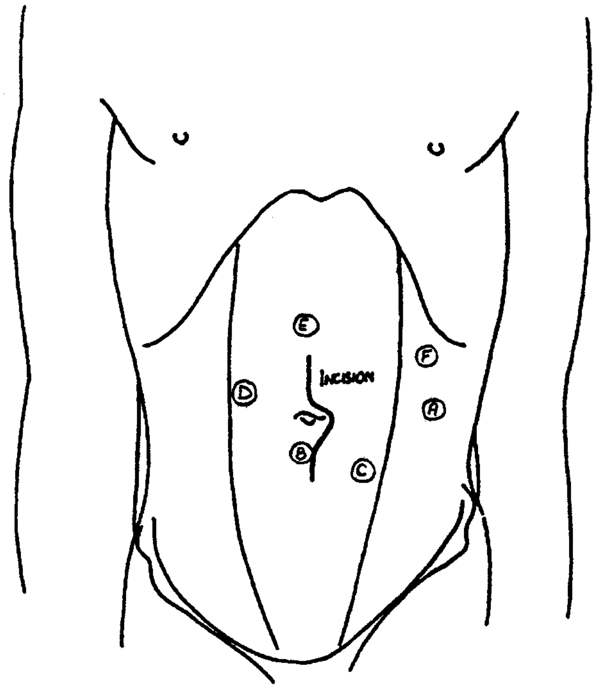

Fig. 1. Placement of trocars for aortic dissection and location of minilaparoromy. *A,* camera; *B,* dissector; *C,* dissector; *D,* bowel retractor; *E,* bowel retractor; *F,* suction.

longed postoperative ileus, and significant postoperative pain.

Because the laparoscopic approach in gallbladder disease has proved successful in decreasing postoperative morbidity and has resulted in a quicker recovery, there has been a great deal of interest in applying this minimally invasive technique to vascular surgery. Several animal studies, case reports, and small series have demonstrated the technical feasibility of laparoscopic vascular surgery for both occlusive and aneurysmal disease.[2-11]

This study was designed to establish the feasibility of laparoscoptically assisted AAA repair (L-AAA) and to investigate the effects of this minimally invasive approach on intraoperative and postoperative variables. This is a review of the first 20 patients to undergo L-AAA at our institution.

METHODS

A feasibility study for laparoscopic replacement of the abdominal aorta was first completed in an animal model.[3] Institutional Review Board approval of the experimental protocol and informed consent was subsequently obtained to perform L-AAA in patients.

The patient selection criteria and operative technique have been previously described.[5] Briefly, selection criteria included patients who were undergoing elective infrarenal AAA repair with a tube graft. Patients were excluded if they had a contraindication to laparoscopy, which included severe pulmonary disease, severe obesity, previous surgery via a midline incision, and involvement of the perirenal aorta or the iliac vessels, which would require more extensive manipulation in these regions. Patients were also excluded if they refused to participate in the study. Lower extremity pneumatic compression devices were applied, and patients were placed in a Trendelenburg position with the legs straight and abducted. The operating surgeon was positioned between the legs while the camera holder (first assistant) and the third assistant stood to the left of the patient. The bowel retractor (second assistant) stood on the right.

We have recently modified some of the operative techniques. The peritoneal cavity is entered through a 1 cm supraumbilical midline cutdown. A modified Glassman viscera retainer "fish" (Adept-Med) is then inserted directly into the peritoneal cavity. A Hasson cannula is introduced and pneumoperitoneum obtained to 15 mm Hg. Under direct visualization, five 10 mm trocars are inserted (Fig. 1). A 30-degree laparoscope is placed into port A. The operating surgeon uses ports B and C for dissection. Ports D and E are used for small bowel retraction. Port F is used for suction or additional retraction as needed. The "fish" is used to expose the AAA and to keep the small bowel away from the AAA. The retroperitoneum at the level of the duodenum is opened with a combination of electrocautery and blunt dissection. The site of aortic cross-clamping at the neck of the aneurysm just inferior to the left renal vein is identified. Laparoscopic dissection is then carried out on the anterior, medial, and lateral surfaces of the aortic neck down to the vertebral bodies. On completion of the neck dissection the "fish" is moved inferiorly, and the right and left common iliac arteries are dissected in a similar fashion.

At the end of the laparoscopic dissection, the trocars are removed and an 8 to 11 cm periumbilical incision is made. A Creech endoaneurysmorrhaphy is performed through this incision using standard open instruments.[12] After 5000 U heparin is given by intravenous injection, the iliac vessels are occluded with straight Fogarty clamps introduced through port incisions B and C, and the neck is controlled with an aortic cross-clamp introduced through port incision E. The aneurysm is opened, and the ostia of the inferior mesenteric and lumbar vessels are oversewn. A polytetrafluoroethylene tube graft is sewn into place using a CV-3 suture. After hemostasis is obtained, the aortic wall is then closed over the graft and the retroperitoneum is closed over the aneurysm sac. All port sites are closed with 0 polyglactin sutures with an Endoclose (U.S. Surgical, Norwalk, Conn.), and the abdominal wound is closed with #1 polydioxanone. After the operation, all patients are taken directly to the intensive care unit (ICU).

All patients in this study were admitted on the day of surgery. An arterial line and pulmonary artery catheter (PAC) were inserted before the induction of anesthesia. Data obtained included heart rate, temperature, pulmonary artery systolic pressure, pulmonary artery diastolic (PAD) pressures, mean arterial pressure, central venous pressure (CVP), pulmonary capillary wedge pressure (PCWP), cardiac index, mixed venous oxygen saturation (MVO_2), and oxygen extraction ratio (O_2Ex).

Transesophageal echocardiographic (TEE) monitoring was available for eight of the 18 patients in whom L-AAA was completed. After laryngoscopy and tracheal intubation, a TEE transducer probe was inserted. Examination of the heart and great vessels was carried out initially. The TEE probe was then positioned to monitor a transgastric transverse plane short-axis view of the midpapillary level of the left ventricle. End diastolic area (EDA) and end systolic area (ESA) were measured off line with manual planimetry. The percent ejection fraction area ($\%EF_a$) was determined from the formula $\%EF_a = [(EDA - ESA) / EDA] \times 100$. All PAC and TEE data were obtained during insufflation, after desufflation but before infrarenal aortic cross-clamping, during aortic cross-clamping, and then at the end of the procedure after hemostasis was achieved.

The patients were admitted to the ICU in the immediate postoperative period per our institution's standard of care, where fluid resuscitation and extubation were performed as per ICU protocol.

Analysis of variance was used to determine statistical significance, which was accepted for p values less than 0.05.

RESULTS

We have completed L-AAA repair in 18 out of 20 patients. The first patient was converted to a standard open repair because of inadequate port placement. The thirteenth patient was converted because of multiple adhesions caused by a previous hysterectomy. Because the laparoscopic procedure was not completed in these patients, they were excluded from data analysis. Both of these patients had an uneventful postoperative course.

In the immediate postoperative period there were two minor complications. One of the patients had mild cellulitis around the minilaparotomy incision, which required 2 additional days of intravenous antibiotics. Rhabdomyolysis developed in another after plaque embolization to the right calf from cross-clamping the right iliac artery. This was successfully treated by intravenous hydration. There was a single major complication of postoperative left colon ischemia. That patient underwent a Hartmann's procedure and subsequently became ventilator-dependent. In addition, one of the patients underwent an uncomplicated L-AAA repair 8 days after undergoing combined coronary artery bypass grafting and aortic and mitral valve replacement. A pericardial effusion developed in that patient after operation and ultimately necessitated a pericardial window. Another had an incidentally discovered early gastric carcinoma and underwent a simultaneous hemigastrectomy. The longest follow-up is 28 months (range, 0.4 to 28 months; mean, 12.4 months) with no long-term complications to date. The patients appeared to return to their preoperative status within 2 to 3 weeks after the operation in terms of their energy level, the level of their activity, and their appetite. There were no deaths in this study.

The mean aneurysm size was 5.3 cm (range, 4 to 7 cm), and the average patient age was 70.9 years (range, 60.9 to 79.1 years). Comorbid medical conditions in this group included hypertension in all but two patients, coronary artery disease in nine patients, and a history of chronic obstructive pulmonary disease in two patients, although 12 patients had an active or former history of smoking. Eighteen out of the 20 patients had at least two coexisting comorbid medical conditions. The total operative time (time of incision to time of closure) was 245.6 ± 55.2 minutes, with a range between 162 and 335 minutes. Laparoscopic time (time of insufflation to the time ports were removed to proceed to the minilaparotomy), which accounted for about 40% of the total operative time, was 84.2 ± 26.9 minutes, with a range of 50 to 140 minutes. A definite learning curve was apparent for both of these variables (Fig. 2). The intraoperative mean blood loss was 1.1 ± 0.7 L, and crystalloid requirement was 6.4 ± 1.6 L (Fig. 3). The patient core tem-

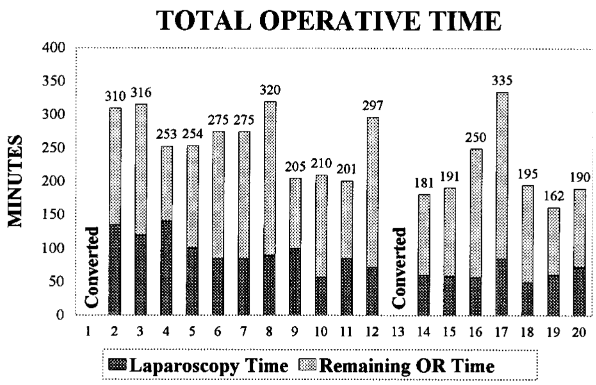

Fig. 2. Laparoscopic and total operating times, excluding patients who were converted to open AAA repair.

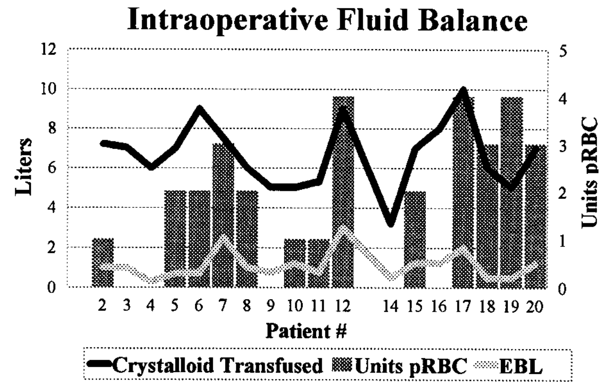

Fig. 3. Balance between crystalloid and packed red blood cells transfused during operation versus blood loss.

Table I. Operative data at different stages of procedure.

	Baseline	*Insufflation*	*Desufflation*	*Cross-clamp*	*Closure*
Heart rate	71.6 ± 11.1	64.0 ± 8.9	64.4 ± 9.2	63.9 ± 11.2	64.1 ± 9.3
Temperature (° C)	36.3 ± 0.5	35.5 ± 0.4	35.0 ± 0.6	35.1 ± 0.7	34.9 ± 0.7
PAS (mm Hg)	31.6 ± 12.5	34.6 ± 5.6	31.8 ± 4.4	29.3 ± 5.6	36.4 ± 6.4
MAP (mm Hg)	104.4 ± 15.0*	92.5 ± 9.0	84.6 ± 9.8	83.4 ± 12.1	87.5 ± 7.4
PCWP (mm Hg)	14.9 ± 10.4	19.9 ± 3.9	17.0 ± 4.5	15.6 ± 7.6	18.8 ± 2.7
CI (L/min/m^2)	2.8 ± 0.5	2.6 ± 0.6	2.9 ± 0.5	2.7 ± 0.5	3.2 ± 0.9
MVO_2 (Po_2)	43.6 ± 5.1	44.0 ± 5.0	48.8 ± 7.9	43.6 ± 7.0	48.0 ± 6.9
O_2Ex (%)	19 ± 6	21 ± 5	17 ± 5	19 ± 6	19 ± 6
ESA (cm^2)	6.7 ± 5.9	7.0 ± 6.9	7.4 ± 6.1	7.7 ± 5.8	7.7 ± 6.8
EDA (cm^2)	13.0 ± 7.9	12.4 ± 7.9	14.4 ± 7.7	13.5 ± 8.5	14.6 ± 9.5
$\%EF_a$†	53.1 ± 20.0	49.8 ± 24.5	52.3 ± 19.4	45.9 ± 17.5	52.3 ± 16.9

PAS, Pulmonary artery systolic pressure; *MAP,* mean arterial pressure; *CI,* cardiac index.
*$p < 0.05$ compared with all other values of MAP.
†%EF is the estimated ejection fraction area determined by the formula: [(EDA – ESA) / EDA] × 100.

perature did not change during the procedure (Table I). Most patients were extubated within hours of the completion of the procedure (Fig. 4). By the end of the first postoperative day, the majority of the patients (16 of 18) were able to have their intravenous fluid rate decreased to 30 to 50 ml/hr and required no further fluid boluses. The mean duration of nasogastric tube (NGT) suction was 1.3 ± 0.7 days; 14 of the 18 patients tolerated a clear liquid diet by the second postoperative day (Fig. 5). The mean ICU stay was 2.2 ± 0.9 days (Fig. 6), and the mean length of hospitalization was 5.8 ± 1.6 days (Fig. 7). The postoperative hospital stay excludes the two patients who underwent additional procedures that were not related to their aneurysms and the patient with left colon ischemia, who had an unusually prolonged postoperative course. The mean hospital stay, including all patients except this last patient, was 8.6 days. This patient was an extreme outlier, with a hospital stay of 198 days, which raised the mean hospital stay to 18.2 days.

TEE monitoring was available for eight patients in this study group. Seven were completed by the L-AAA method successfully. One patient was converted to open AAA repair because of adhesions that had formed from a previous hysterectomy. That patient's data were still used for hemodynamic analysis because we were able to obtain all parameters during pneumoperitoneum.

For this group of patients the mean operative time was 3.77 ± 1.0 hours. No changes were noted in heart rate, temperature, pulmonary artery systolic pressure, PCWP, cardiac index, MVO_2, or O_2Ex. There were also no changes in ESA, EDA, and $\%EF_a$ (Table I). However, both PAD and CVP were greater during insufflation than during baseline (Fig. 8). Mean arterial pressure was significantly greater at baseline compared with all other times during the procedure (Table I).

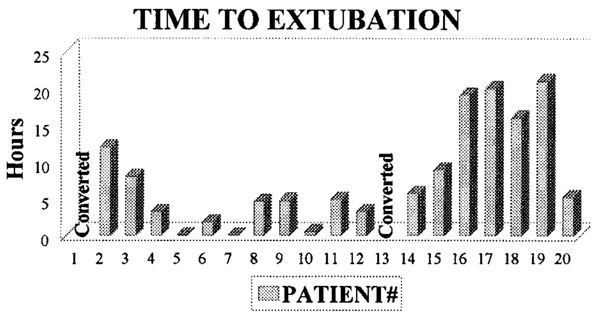

Fig. 4. Hours to extubation. Data excludes patients who were converted to open AAA repair.

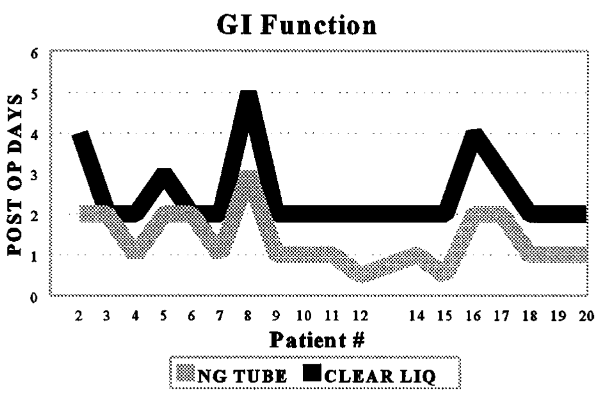

Fig. 5. Duration of NGT suction and interval to tolerating a clear liquid diet.

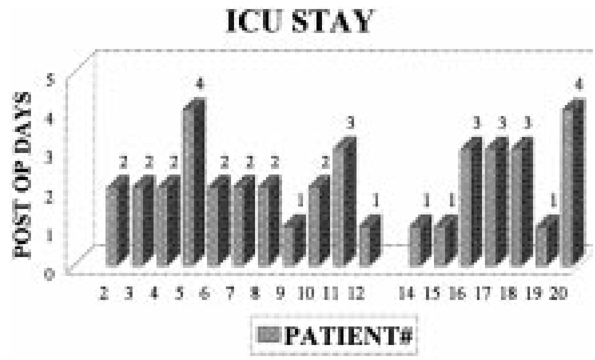

Fig. 6. Duration of postoperative recovery in ICU.

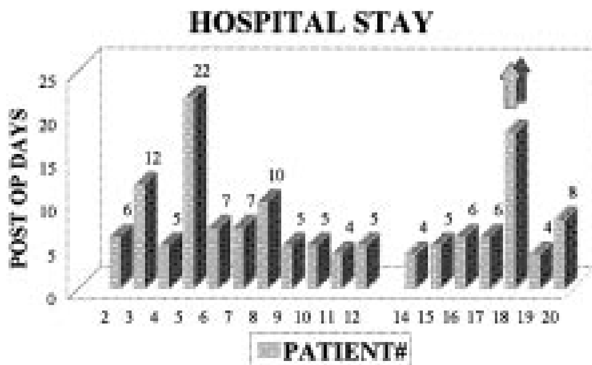

Fig. 7. Length of hospitalization. Data excludes patients who were converted to standard open AAA repair.

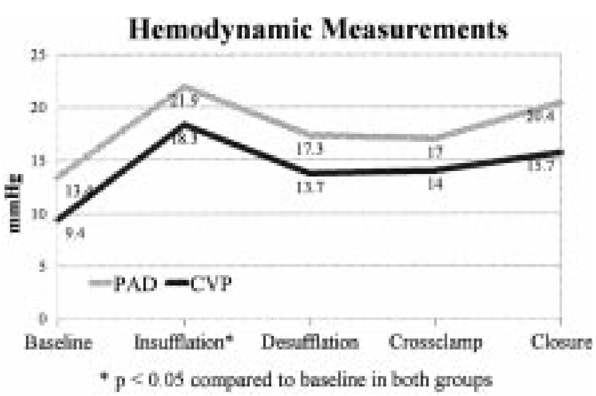

Fig. 8. PAC-derived measurements. PAD and CVP values are significantly increased during insufflation.

The pain management of these patients was under the control of our anesthesia pain service. The majority of all of our AAA patients, both open and laparoscopic, received an epidural that was maintained after the operation. In this group, 15 of 20 patients had an epidural placed, and the remaining five were on intravenous patient-controlled analgesia for control of postoperative pain. Of the 15 patients who had epidural patient-controlled analgesia, 14 were able to tolerate the removal of the epidural by the second postoperative day. Thirteen of the 18 patients in whom the laparoscopic dissection was completed were on oral medication by postoperative day three, six of whom only required acetaminophen for pain control. Of the remaining five patients, one was the patient who also required a gastrectomy and had her incision extended, and one was the patient who had rhabdomyolysis.

DISCUSSION

Elective procedures for aneurysmal disease are performed routinely and safely with mortality rates of 3% to 5%.[1] However, exposure of the abdominal aorta typically requires a long midline incision extending from xiphoid to pubis or a long flank incision that crosses multiple dermatomes and muscle groups. Both incisions are associated with considerable postoperative pain. This larger incision contributes to respiratory impairment, which in turn leads to atelectasis and occasionally pneumonia. Bowel manipulation contributes to fluid shifts, decreased core temperatures, prolonged postoperative ileus, increased ICU stay, and increased hospital stays.

In recent years, the use of laparoscopy in abdominal surgery has increased exponentially, especially in older and cardiovascularly compromised patients, because it has been shown to decrease postoperative pain and lead to a quicker recovery toward a full functional status. The same benefits appear to hold true with its use in vascular surgery. One of the apparent advantages of the L-AAA repair are related to the decreased small bowel manipulation by use of the "fish" and hence the apparent decreased third spacing of fluids and shorter period of postoperative ileus, as witnessed by a quicker removal of the NGT and advancement to clear liquid diet than seen with our average aneurysm patients, who typically do not start a diet until day three to four. Further analysis of these issues will be addressed by a prospective study to directly compare open repair with L-AAA repair in a blinded fashion.

Open AAA repair is associated with postoperative hypothermia, which can result in hemodynamic compromise and coagulopathy.[13] It is important that the core temperature did not change during the L-AAA procedure (Table I). The conditions under which L-AAA is performed allow for minimal heat loss. The laparoscopic portion is done with a warming CO_2 insufflator, and the minilaparotomy used to sew in the graft does not result in significant heat loss. The normothermia potentially contributes to a smoother postoperative course with less of the postoperative fluid requirements seen in open AAA repairs as the patients warm up.

The total operative time for L-AAA was comparable with that of standard open AAA repair, which on average in our institution is 3 to 4 hours. The length of the laparoscopic portion of the dissection comprised about 40% of the total operative time, and it decreased as experience with the procedure was gained (Fig. 2), not unlike most open aneurysm repairs.

As with standard open AAA repair, the majority of the blood loss occurred after opening the aneurysm and before controlling the backbleeding from the patent lumbar vessels. Although we expected the intraoperative fluid requirements to be minimized by the use of laparoscopy, the mean amount of isotonic fluid transfused was 6.4 ± 1.6 L (Fig. 3). Interestingly, patients started diuresing almost immediately after operation and required only maintenance volume during the next 24 hours. Also, all patients were extubated within hours of the completion of the procedure (Fig. 4). All patients had a brief postoperative ileus, as manifested by the early removal of the NGT and the resumption of a clear liquid diet by the second postoperative day. The patients appeared to have less postoperative pain because the majority of patients were able to have their pain controlled with oral medication only by postoperative day three and one third of patients by regular acetaminophen alone.

Understanding the hemodynamic effects of pneumoperitoneum in the vascular patient has become of foremost importance. Intraoperative monitoring of such patients has traditionally included radial artery catheters and PACs. However, the accuracy of the hemodynamic parameters obtained from these devices during pneumoperitoneum has been questioned in the recent literature.[14] The addition of intraoperative TEE monitoring has expanded the wealth of available intraoperative information, allowing for timely management of any adverse occurrences.

The use of intraoperative TEE has increased in recent years. It has a very high sensitivity for myocardial ischemia, which manifests as wall motion abnormalities. In addition, it has been shown to be a valuable adjunct for volume resuscitation in patients who are undergoing open infrarenal AAA repair.[15] In the beginning of our L-AAA study, it came to our attention that the pulmonary artery pressures always appeared to increase during insufflation and decrease with desufflation. If this were so, then the hemodynamic variables measured during pneumoperitoneum would not reflect the true volume and pressure status. This prompted the addition of intraoperative TEE monitoring to the standard PAC.

No changes were noted in heart rate, temperature, pulmonary artery systolic pressure, PCWP, cardiac index, MVO_2, or O_2Ex. The mean arterial pressure was significantly greater at baseline than at any other time during the procedure (Table I). Because the baseline measurements were taken before induction of anesthesia, patient anxiety probably produced an artificially elevated blood pressure. Inhalational anesthetics produce peripheral vasodilation as well as cardiac depression. The combination of these two factors is the likely cause for the difference seen. We have since changed the timing of baseline measurements to just after the induction of anesthesia but before skin incision for a more accurate comparison with the measurements obtained during the procedure.

The PAD and CVP increased significantly when compared with baseline (Fig. 8). However, the PCWP, and more importantly the EDA, on TEE did not change. The PAC measures pressures in the pulmonary arterial tree. Although volume status is the primary determinant of PAD, other factors such as positive pressure ventilation and elevation of the diaphragm by the pneumoperitoneum influence the parameters measured.

The advantage of using TEE is its independence of intrathoracic pressure. Ventricular function and filling can be monitored on a continuous basis, and any adverse effects that pneumoperitoneum may have on preload or ventricular contractility are readily apparent. The EDA obtained during TEE has been shown to be a reliable method of determining intravascular volume status.[16] Given the changes seen with PAD and CVP, which are probably inaccurate because of artificial elevation from pneumoperitoneum, TEE may be a better alternative to monitor cardiovascular status.

Our data showed that there was no significant increase in preload during any part of the procedure as measured by the EDA on TEE. The $EF\%_a$ was also unchanged. In addition, monitoring ventricular contractility and myocardial ischemia as manifested by wall motion abnormalities may make TEE a superior method to observe these patients during the operation.

This small series demonstrates that L-AAA is a technically feasible and reproducible approach to the treatment of elective AAA. Potential advantages may include quicker recovery times as a result of decreased small bowel manipulation and third spacing of fluids, leading to decreased postoperative ileus. Although we have preformed totally laparoscopic repairs in animals, the lack of the ability to safely and reliably control the lumbar vessels in human L-AAA repair has prevented the consideration of a totally laparoscopic repair of aneurysmal disease. The presence of the aneurysm does not allow for manipulation as easily as in aortic occlusive disease. It is our opinion that the standard repair of the aneurysm should not be altered to allow the performance of a total laparoscopic repair, for instance via an exclusion technique. Operative times and technical expertise improved during the time of the study. A prospective randomized study is now underway at our institution to determine whether this minimally invasive approach to the treatment of abdominal aneurysmal disease is advantageous.

REFERENCES

1. DeBakey ME, McCollum CH. Surgical treatment of nonruptured infrarenal and juxtarenal abdominal aortic aneurysms. In: Ernst CB, Stanley JC, editors. Current therapy in vascular surgery. 2nd ed. Philadelphia: B.C. Decker Inc., 1991:261-4.
2. Byrne J, Hallett JW, Kollmorgen CF, Gayari MM, Davies W. Totally laparoscopic aortobifemoral bypass grafting in an experimental model: description of technique with initial surgical results. Ann Vasc Surg 1996;10:156-65.
3. Chen MH, Murphy EA, Levison J, Cohen JR. Laparoscopic aortic replacement in the porcine model: a feasibility study in preparation for laparoscopically assisted abdominal aortic aneurysm repair in humans. J Am Coll Surg 1996;183:126-32.
4. Jones DB, Thompson RW, Soper NJ, Olin JM, Rubin BG. Development and comparison of transperitoneal and retroperitoneal approaches to laparoscopic-assisted aortofemoral bypass in a porcine model. J Vasc Surg 1996;23:466-71.
5. Chen MHM, D'Angelo AJ, Murphy EA, Cohen JR. Laparoscopically assisted abdominal aortic aneurysm repair: a report of 10 cases. Surg Endosc 1996;10:1136-9.
6. Dion YM, Gaillard F, Demalsy JC, Gracia CR. Experimental laparoscopic aortobifemoral bypass for occlusive aortoiliac disease. Can J Surg 1996;39:451-5.
7. Ahn SS, Clem MF, Braithwaite BD, Concepcion B, Petrik PV, Moore WS. Laparoscopic aortofemoral bypass: initial experience in an animal model. Ann Surg 1995;222:677-83.
8. Chen MH, Murphy EA, Halpern V, Faust GR, Cosgrove JM, Cohen JR. Laparoscopic-assisted abdominal aortic aneurysm repair. Surg Endosc 1995;9:905-7.
9. Berens ES, Herde JR. Laparoscopic vascular surgery: four case reports. J Vasc Surg 1995;22:73-9.
10. Dion YM, Chin AK, Thompson TA. Experimental laparoscopic aortobifemoral bypass. Surg Endosc 1995;9:894-7.
11. Dion YM, Katkhouda N, Rouleau C, Aucoin A. Laparoscopy-assisted aortobifemoral bypass. Surg Laparosc Endosc 1993;3:425-9.
12. Creech O. Endoaneurysmorrhaphy and treatment of aortic aneurysms. Ann Surg 1966;164:935-46.
13. Kahn H, Faust G, Richard R, Doscher W, Cohen JR. Hypothermia and bleeding during abdominal aortic aneurysm repair. Ann Vasc Surg 1994;8:6-9.
14. Harris SN, Ballantyne GH, Luther MS, Perrino AC Jr. Alterations in cardiovascular performance during laparoscopic colectomy: a combined hemodynamic and echocardiographic analysis. Anesth Analg 1996;83:482-7.
15. Gillespie DL, Connelly GP, Arkoff HM, Dempsey AL. Left ventricular dysfunction during infrarenal abdominal aortic aneurysm repair. Am J Surg 1994;168:144-7.
16. Swenson JD, Harkin C, Pace NL, Astle K, Bailey P. Transesophageal echocardiography: an objective tool in defining maximum ventricular response to intravenous fluid therapy. Anesth Analg 1996;83:1149-53.

Submitted June 9, 1997; accepted Sep. 2, 1997.

DISCUSSION

Dr. John W. Hallett, Jr. (Rochester, Minn.). The premise of this work is that laparoscopically assisted abdominal aortic aneurysm repair is physiologically less stressful on human beings than standard surgical procedures. At the Mayo Clinic, we have investigated this hypothesis in the experimental laboratory. Physiologic and hemodynamic stress was compared in three groups of dogs: (1) standard surgical therapy; (2) minilaparotomy; and (3) total laparoscopic aortic replacement. We examined a number of physiologic, metabolic, and hemodynamic parameters in the early postoperative period and at 1 month. To our surprise, we could not demonstrate that laparoscopic abdominal aortic surgery was less stressful in the laboratory animal than standard surgery. Whether one makes one long midline incision or multiple laparoscopic punctures, the stress response is similar.

I am interested in whether you have other metabolic data on your patients, such as catecholamine levels and nitrogen balance?

Dr. Jon R. Cohen. We have not looked at any of those issues to date. I can tell you that I'm personally not convinced at all whether this is real or not. I can tell you anecdotally that the patients in whom we have performed this procedure, where it has gone well they do extraordinarily well. This is like a minilaparotomy incision. It is amazing to see them on the first postoperative day sitting up ready to eat and ready to go home by the third or fourth day. Whether that means anything in the long term is certainly up for discussion. I'm not going to tell you whether a patient who has a standard repair who goes on home on day 7 is much different than this. But I can tell you that anecdotally the patients look better at several days.